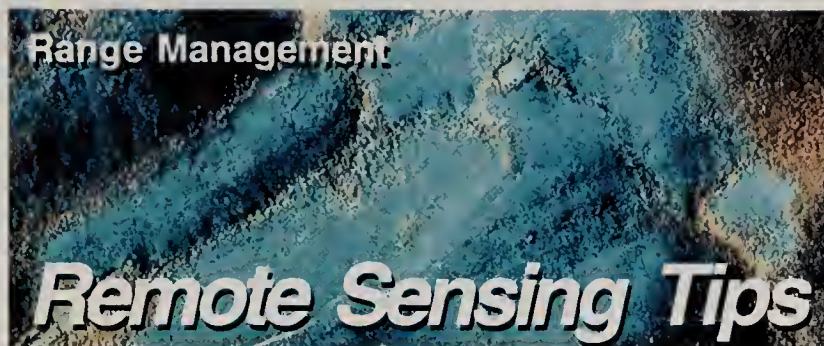


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Mapping and Monitoring Noxious Weeds Using Remote Sensing

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Leonard Lake and Bruce Anderson
Nez Perce National Forest, Grangeville, Idaho

Vicky Varner and Henry Lachowski
Remote Sensing Applications Center, Salt Lake City, Utah

Overview

The invasion and spread of noxious weeds has become an ever-increasing problem throughout the United States. Noxious weeds are typically not native to the area they are invading and often grow unchecked by natural predators such as insects. A common characteristic of most noxious weeds is their aggressive, competitive growth.

Noxious weeds become established in soil disturbed by construction, travel, or recreation and are then transported by wildlife, livestock, wind, water, vehicles, and people to new sites. Once established, they are able to invade adjacent undisturbed plant communities, where they tend to crowd out native species while failing to offer replacement value to the ecosystem.

Current ground-based surveys are expensive and result in slow detection and limited information on the extent and spread of noxious weeds. This project tested the feasibility of using various types of remote sensing imagery to detect and map four noxious weeds along river corridors inside and neighboring the Frank Church River of No Return Wilderness in central Idaho. The weeds selected were yellow starthistle (Figure 1), spotted knapweed, leafy spurge, and rush skeletonweed because there are large known infestations of each in geographically distinct areas outside the wilderness area.



Figure 1. A site infested with yellow starthistle.

For additional information contact: Henry Lachowski, Remote Sensing Applications Center, 2222 West 2300 South, Salt Lake City, UT 84119; phone: (801) 975-3660 (WO3A) or Deb Hayes, Noxious Weeds Coordinator, Range Staff, Washington Office, Washington, DC; phone: (202) 205-0847.

Susceptibility Modeling

Many noxious weeds have specific site requirements that can be modeled to identify habitat susceptible to invasion and possibly the degree of susceptibility (low, moderate, or high). The cost of data acquisition can be better allocated or even reduced by knowing where a habitat is susceptible to invasion and how susceptible it is. A model of the method of mapping susceptible habitat is shown in Figure 2. Layers such as cover type, elevation, aspect, and slope, stored in a geographic information system (GIS), can be used to model susceptible habitat. Other data layers in a more complex model include soils, recreation features such as trails and campsites, and wind patterns. Information from these models can be used to focus data collection efforts.

Data Acquisition

Aerial remote sensing data were acquired with a color infrared digital camera, a multispectral video camera, and conventional 70-mm and 35-mm cameras. These images were obtained in mid-July 1996 at two altitudes: (1) 7,000 feet above ground level (AGL) over the center of the river with a digital-camera-image swath width of 1 mile, and (2) 3,500 feet AGL over each side of the river with a swath width of ½ mile. The time period was selected to correspond with some stage of flowering in the four weeds.

Image Interpretation

All interpretations were made by forest personnel, with field validation of known infestations. In general, field validation revealed that the image interpretations were too conservative, encompassing robust weed population centers but missing many low-density areas (Figure 3).

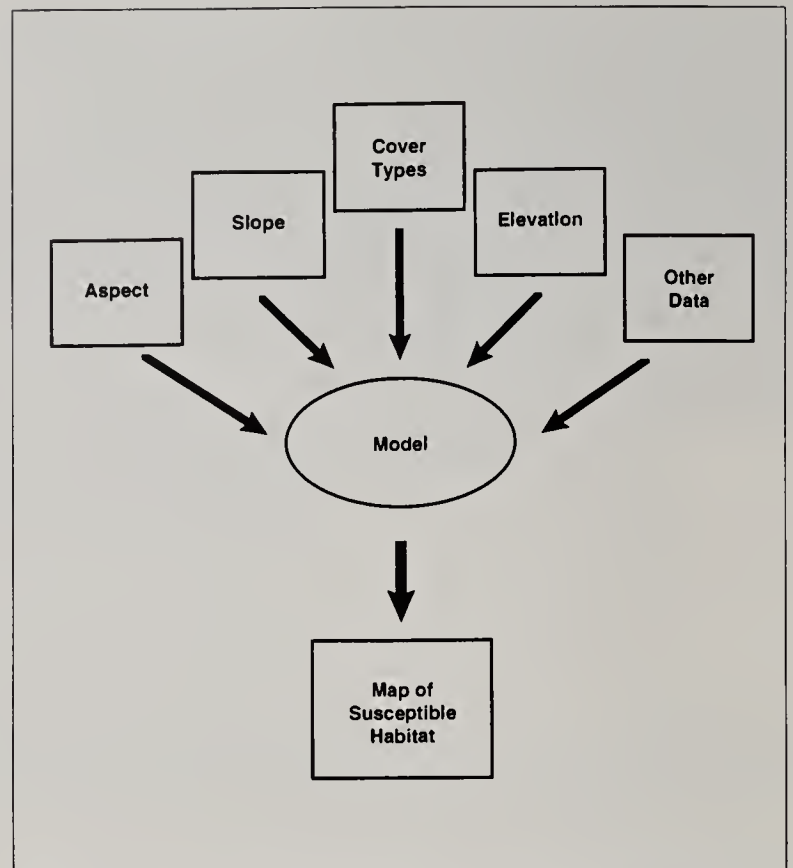


Figure 2. A conceptual model for creating a map of susceptible habitat.

Infestations were most evident in the 70-mm color photographs (Figure 4), which had the finest ground resolution and largest footprint (area covered by a single frame) of all the aerial data acquired at the same altitude. However, the cost and time required for processing film, locating the photos on a map, and converting this imagery to a digital format for use in a GIS can be prohibitive.

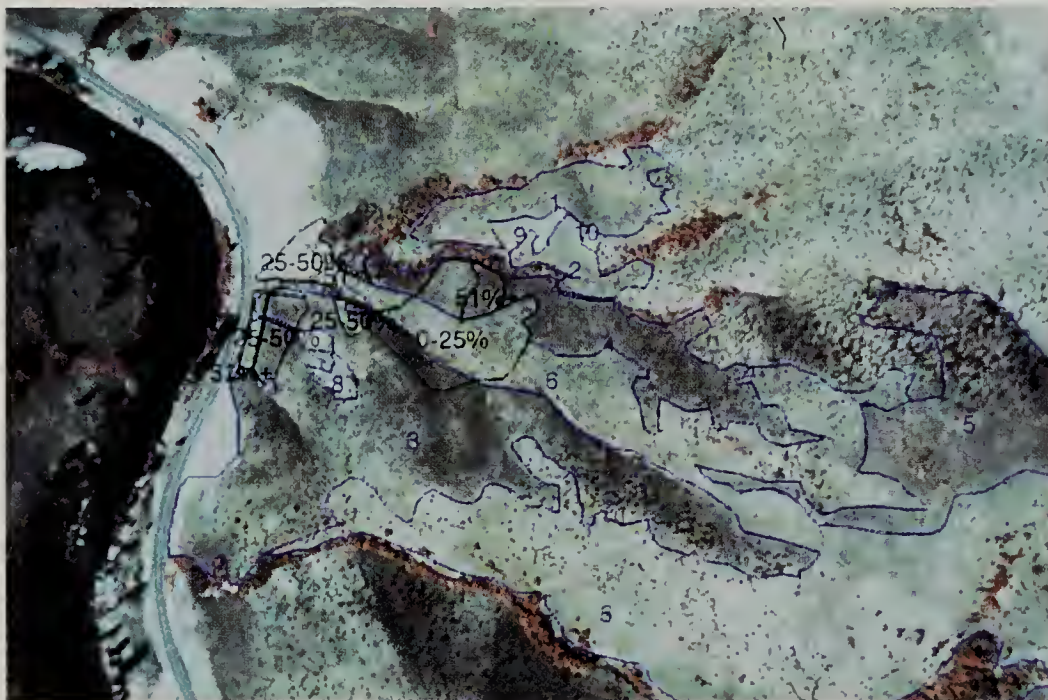


Figure 3. A digital camera image of a rush skeletonweed site. The blue polygons represent on-screen digitizing, and the black polygons represent the field validation. Percentages describe the extent of infestation.

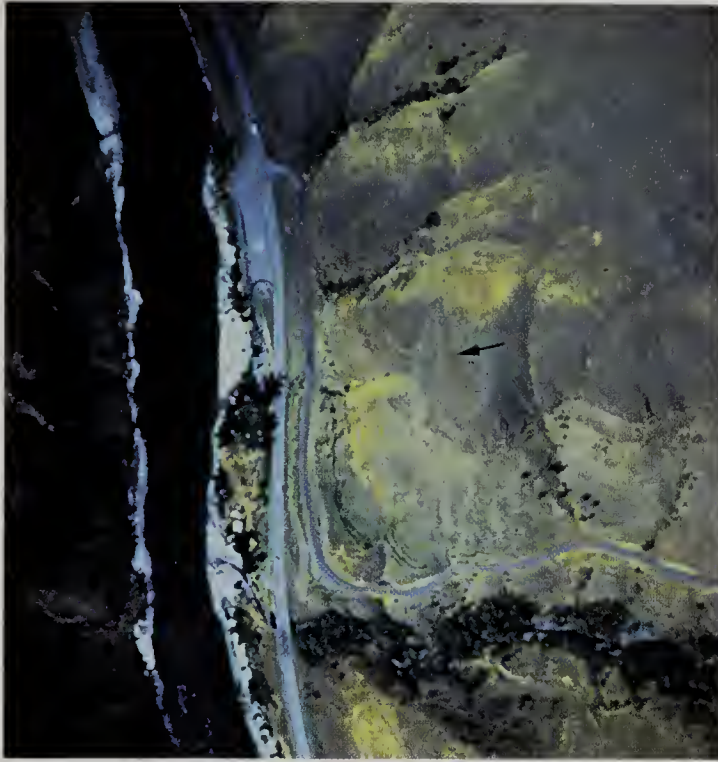


Figure 4. Yellow starthistle as seen on a natural-color photograph. The arrow points to an area of infestation.

Infestations were less apparent on images from the color infrared digital camera (Figure 5), which has a coarser resolution and a smaller footprint. The main advantages of this type of imagery are (1) it is acquired in a digital format, (2) it has general location information from a global positioning system that is linked to each image, and (3) the images can be viewed immediately after they are acquired. Digital camera technology such as chip size, storage capacity, and recycle time keeps improving. A higher resolution can be achieved by flying at a lower altitude or changing the focal length of the camera lens. These strategies will increase the number of frames of digital imagery but should remain cost effective for a typical project area.

The multispectral video imagery (Figure 6) offered a narrow, multiband capability to extract information that is not available by using the other cameras. This imagery is best used as a spot sampling tool because of the time required to convert it into an interpretable format.

Results

The timing of data acquisition was the most critical factor in distinguishing noxious weeds from surrounding cover. The presence of gray skeletal plant stems was the visual key for both spotted knapweed and yellow starthistle infestations. The detection of new infestations may be improved by determining if unique phenological characteristics can be seen from the air. For example, most weeds

“green up” earlier in the spring and stay green later in the fall than surrounding native vegetation. Rush skeletonweed, which was not apparent on any of the aerial imagery, may be detectable during these seasons. Leafy spurge, which was studied during an optimal time frame, was apparent on all the aerial imagery.

Data at various levels of resolution that cover small to large areas at a specific point in time can be provided by remote sensing. This comprehensive perspective is useful in the management planning process to assess the current situation and answer questions such as the following: “Where do we have a problem with noxious weeds?” “How extensive is the noxious-weed infestation?” “Where is the infestation likely to spread?” “What areas are not likely to be affected?” It can also help establish a baseline for monitoring, predicting future change, or planning and evaluating the effectiveness of weed-control programs.

Costs

Data acquisition for a project area of 10,000 acres would require 1 day of flight time. The cost would be about \$4,500. This includes rental of an aircraft with pilot, use of equipment for data acquisition, and the services of two people for data support. A digital camera acquiring data at a nominal ground-resolved distance of 1 meter with 35 percent sidelap and endlap would produce 115 images. It would take roughly 2 weeks to process and analyze these images.

Summary and Recommendations

Aerial data collection should occur during the period when the reflective characteristics of the plant are most distinct. The length of the optimum phenological window will vary among species and sites. This factor adds

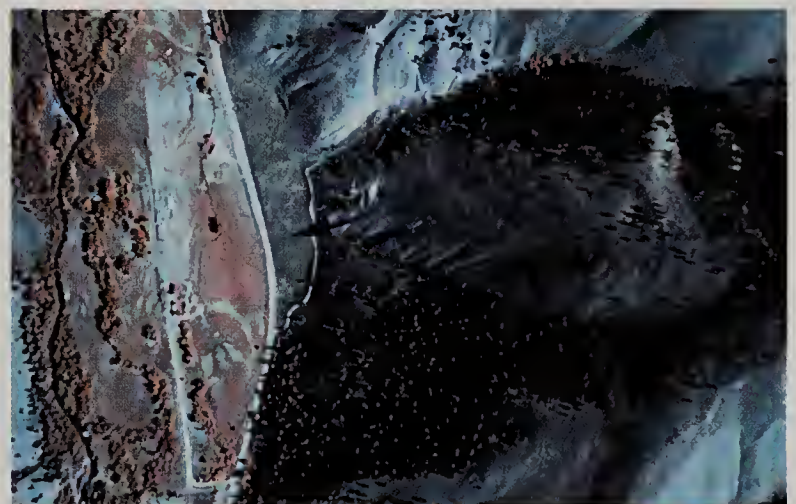


Figure 5. A digital camera image showing a spotted knapweed infestation.



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Figure 6. A multi-spectral video image showing a leafy spurge infestation. The arrow points to leafy spurge.

complexity to a project where more than one weed is targeted for identification. In addition, the varying slopes, aspects, and elevations of this particular study area made detection of small infestations, as well as early identification of any invading weeds, difficult with this set of aerial data. The ability to detect small or early infestations of noxious weeds may be improved in more homogeneous landscapes.

This study tested the feasibility of detecting and mapping four noxious weeds at one time, during peak flowering. However, a single flight period did not capture the optimum phenology for all of the plants. Of the four noxious weeds, leafy spurge was the easiest to detect at an early stage of infestation. In mid-July, small or sparsely populated infestations of spotted knapweed and yellow starthistle were difficult to identify consistently from the imagery. Rush skeletonweed could not be identified at all from the imagery because of its physiological characteristics. Yellow starthistle, spotted knapweed, and rush skeletonweed may have distinctive signatures outside the peak flowering period. Future projects should explore aerial data collection during autumn or early winter for rush skeletonweed and early summer or late winter for yellow starthistle. These unique phenological time periods may yield better detection and mapping results.

Coarse resolution satellite imagery like Landsat Thematic Mapper provides broad areal coverage (approximately 8 million acres per scene). This imagery can be organized into classes representing general vegetation or land cover

patterns, which can then be incorporated into susceptible habitat models. Information from the model and plant physiology will determine areas to be flown, aircraft altitude, and optimum focal length of the camera lens.

Suggested Readings

- Everitt, J.H., D.E. Escobar, and M.R. Davis. 1995. Using remote sensing for detecting and mapping noxious plants. *Weed Abstracts*, 44(12), 639–649.
- Lachowski, H., V. Varner, and P. Hardwick. 1997. *Mapping and Monitoring Noxious Weeds Using Remote Sensing* (draft internal report). Salt Lake City: Remote Sensing Applications Center.
- Prather, S.T. and R.H. Callihan. 1986. Weed eradication using geographic information systems. *Weed Technology*, 7, 265–269.
- Pulling Together: National Strategy for Invasive Plant Management* (multiagency report). 1997. Washington, DC: Federal Interagency Committee for Management of Noxious and Exotic Weeds.
- Varner, V., H. Lachowski, and P. Maus. 1996. *Noxious Weeds and Remote Sensing* (internal report). Salt Lake City: Remote Sensing Applications Center.
- Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. 1996. *Weeds of the West*. Newark, CA: Western Society of Weed Science in cooperation with Western United States Land Grant Universities Cooperative Extension Services.